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SCIENTIFIC PAPERS.

JUGLANDACEAE OF THE UNITED STATES.

BY WILLIAM TRELEASE.

In 1893-4, a study of the North American Juglandaceae was made, which led to the preparation of a synoptical revision of the species occurring in the United States, but as several supposed hybrids had been received in fruit, which it was desirable to have represented by material showing flowers and foliage, the manuscript was laid aside for a year and again taken up in the fall of 1894. At that time, however, more fruiting material requiring additional summer collections was received, so that the revision, as then completed, was again laid aside. In February, 1895, the seventh volume of Professor Sargent's *Silva of North America* appeared, so that it is not now considered desirable to publish the entire manuscript I had prepared. The following pages, therefore, contain merely such a tabulation of the fruit, twig, bark and bud characters as it is thought will be helpful in field studies, with notes on the hybrid forms referred to.

In a memoir published in 1862,* as well as in a descriptive monograph of the Juglandaceae,† M. De Candolle makes use of certain characters derivable from the winter buds, by which not only the large groups but even some species of hickory may be distinguished; and, in fact, most of the species are more readily known in their winter condition than during the period of flowering or the early summer season. This is also true of the walnuts, where differences

* *Annales des Sciences naturelles, Bot.*, ser. 4, xviii. 1.

† *DC. Prodromus*, xvi. (2), 142, 144.

in the pith are added to those observable in the buds and bark.*

Professor Britton, in an article published in 1888, restoring the Rafinesquian name *Hicoria* for the genus which had so long been known as *Carya*,† bases a primary subdivision of the genus upon the location of the staminate catkins, this grouping being somewhat different from that of De Candolle. It seems to me, however, that the bud, fruit, and inflorescence characters are complementary to one another, the lateral umbels of the Pecan, which were held by Britton to be peculiar, resulting merely from the abortion of many of the shoots on which they are basal, and I am glad to see that Professor Sargent, in his recent treatment of the genus, has come to substantially the same conclusion. In the following pages, therefore, Britton's subgenus *Pacania* has been amplified so as to include all of the species comprised in the section *Apocarya* as understood by De Candolle.‡ This being done, *Eucarya* of De Candolle and Engler, and *Euhicoria* of Britton, have an identical limitation. In the main I quite agree with Professor Sargent § in the limitation of species, and the nomenclature of the *Silva* is followed unless the contrary is specifically stated, so that this paper is not incumbered with the detailed synonymy of each species, which can easily be ascertained by reference to the *Silva*.

During the past year Nawaschin || has ascertained that the pollen tube of *Juglans regia* reaches the embryo sac by growing through the walls of the ovary and the chalaza instead of passing through the cavity of the ovary and the micropyle, a phenomenon previously discovered in *Casuarineae*, *Myricaceae*, *Betulaceae*, etc., and supposed to

* See Beal, *American Naturalist*, xv. 32.

† *Bulletin of the Torrey Bot. Club*, xv. 277.

‡ See also Engler & Prantl, *Pflanzenfamilien*, iii. (1), 25.

§ Sargent, *Silva of North America*, vii. 132, 134.

|| *Bot. Centralblatt*, lxiii. 353-7; *Smith, Am. Nat.* xxix. 1103; Goodale, *Am. Journ. Sci.* 3 ser. l. 429.

indicate a transition from the Gymnosperms to the Angiosperms, and, by implication, great antiquity for the groups of the latter in which it occurs.

In their pollination, the Juglandaceae are strictly anemophilous.* While the staminate and pistillate flowers of a given tree generally develop simultaneously in *Hicoria*,† Pringle ‡ has observed a tendency to a separate development of the two sorts of flowers, and Meehan § states that in some cases a number of warm days in winter suffice to cause the staminate catkins to develop long in advance of the pistillate flowers. In *Juglans regia*, Kirchner || has noticed that the staminate and pistillate flowers of a given tree develop together, but Meehan ¶ has observed protandry of a month or more on certain walnut trees, after a winter with mild days, and De Candolle ** also makes record of protandry in this genus. In 1875, Delpino †† called attention to the curious circumstance that certain trees of the European walnut are protandrous while others are protogynous, a fact commented on by Darwin ‡‡ and verified for the American *J. cinerea* by Pringle, §§ in 1879, the staminate flowers of one lot of trees blooming simultaneously with the pistillate flowers of others, the other sex of both lots also developing synchronously some ten days later. Kerner ||| states that the staminate flowers open explosively.

* H. Mueller, Bienen Zeitung, 1882, 23; Engler & Prantl, Pflanzenfamilien, iii. (1), 21.

† De Candolle, Ann. Sc. nat. 4 ser. xviii. 12. On the presumable power of self-fertilization in the Pecan, see Meehan, Bot. Gaz. v. 11.

‡ Bot. Gazette, iv. 237.

§ Proc. Phila. Acad. 1885, 117.

|| Neue Beobachtungen über die Bestäubungseinrichtungen einheimischen Pflanzen, Stuttgart, 1886, 13.

¶ l. c. 117.

** l. c. p. 12.

†† Nuovo Giorn. Bot. Ital., vii. 148; Ulteriori Osservazioni, ii. (2), 337.

‡‡ Different Forms of Flowers, 10.

§§ Bot. Gazette, iv. 237.

||| Verhandl. Zool.-bot. Gesellschaft., Wien, 1887, xxxviii. p. 28.

The principal literature of the wood, twig and bud differences of the genera *Hicoria* and *Juglans* is indicated in the following list. A generic key, based on wood structure, is given by Solereder, *Holzstruktur*, 246, and one based on bark characters is given by Moeller, *Anat. Baumrinden*, 308, while a bud synopsis is given by De Candolle, in the memoir cited, p. 8.

HICORIA.

General.

Winter Characters.

Brendel, *Tree in Winter* (Bull. Ill. Lab. Nat. Hist. i.), 28, 30, pl. 4, f. 18. — Damaskinos and Bourgeois, *Bull. Soc. Bot. de France*, v. 610. — Diez, *Flora*, 1887, 550. — Feist, *Schutz Einrichtungen der Laubknospen*, 327–8. — Foerste, *Bot. Gaz.* 1892, 182–3.

Histological Characters.

Hartig, *Anat. Unterscheidungsmerkmale Hölzer*, 9; 3d ed. 18; Engl. transl. by Somerville, 33; *Bot. Zeitung*, 1859, 106. — Houlbert, *Ann. Sci. Nat., Bot.* 7 ser. xvii. 161. — Mayr, *Waldungen N. Amer.* 153. — Solereder, *Holzstruktur*, 244.

H. alba.

Winter Characters.

Brendel, *l. c.* pl. 2, f. 20. — De Candolle, *Mémoire Juglandées*, 7–8. — Foerste, *Bull. Dennison Univ.* i. 30. — Hitchcock, *Key to Kas. Trees*, 6.

Histological Characters.

Houlbert, *l. c.* 162. — Hough, *Amer. Woods*, iv. 90 (3 sects. wood). — Moeller, *Beitr. z. Vergl. Anat. des Holzes*, 95.

H. aquatica.

Winter Characters.

De Candolle, *l. c.* 7–8, f. 4.

Histological Characters.

Houlbert, *l. c.* 161. — Hough, *Amer. Woods*, v. 115 (3 sects. wood).

H. glabra.

Winter Characters.

De Candolle, *l. c.* 7-8, f. 5-6.—Feist, *l. c.* 336.—Foerste, Bull. Dennison Univ. i. 30.—Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 163.—Rothrock, Good and Bad Timber, f. *c-d*.

H. glabra, microcarpa.

Winter Characters.

Bailey, Amer. Gard. xi. 381, 385-8.—Foerste, Bull. Dennison Univ. i. 30.

Histological Characters.

Hough, Amer. Woods, iv. 91 (3 sects. wood).

H. laciniosa.

Winter Characters.

De Candolle, *l. c.* 7, 8.—Foerste, Bull. Denn. Univ. i. 30.—Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 162.

H. minima.

Winter Characters.

Brendel, *l. c.* pl. 2, f. 22.—De Candolle, *l. c.* 7-8.—Feist, *l. c.* 328.—Foerste, Bull. Denn. Univ. i. 30.—Hitchcock, Key to Kas. Trees, 6, f. 16-17; Opening of Buds, 138, f. 102-3; Plants of Manhattan, 18.

Histological Characters.

Gnetzsch, Radiale Verbindungen der Gefäße. Dissert. 1888, 19.—Gris, Moelle des Plantes Ligneuses, 279; Extr. Moelle Pl. Lign. 31, pl. 6, f. 7, 7, f. 10.—Hough, Amer. Woods, ii. 37 (3 sects. wood).—Kny, Abnormität in d. Abgrenzung der Jahresringe, 4.—Moeller, Anat. Baumrinden, 312, with figure.

H. ovata.

Winter Characters.

Bailey, Amer. Gard. xi. 386-7.—Brendel, *l. c.* 29, 30, pl. 2, f. 19, pl. 4, f. 17.—De Candolle, *l. c.* 7.—Döll, Laubknospen Amentaceen, 21, f. 18.—Foerste, Bull. Denn. Univ. i. 30, f. 2.—Hitchcock, Key to Kas. Trees, 6, f. 18; Pl. Manhattan, 18.—Rothrock, Forest Leaves, iv. 56, figures.

Histological Characters.

Brooks, Wood Sections, 15 (radial and tang. sects. wood.—The cross section is *Fagus*).—Hough, Amer. Woods, ii. 36 (3 sects. wood).—Houlbert, *l. c.* 162.—Mayr, Waldungen N. A. 158, figs.—Moeller, Anat. Baumrinden, 311, fig.—Moeller, Vergl. Anat. Holz. 95, f. 67.—Wiesner, Rohstoffe, 615, f. 79.

H. Pecan.

Winter Characters.

Brendel, *l. c.* 31, pl. 2, f. 21.—De Candolle, *l. c.* 7-8, f. 3.—Foerste, Bull. Denn. Univ. i. 30, f. 3.—Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 162.

JUGLANS.

General.

Winter Characters.

Beal, Amer. Nat. xv. 32.—Bösemann, Deutschland's Gehölze im Winterkleide, 60.—Brendel, *l. c.* 28.—Damaskinos & Bourgeois, *l. c.* 610.—De Candolle, *l. c.* 7-8.—Foerste, Bot. Gaz. 1892, 182-3, fig. 20.—Wilkomm, Laubhölzer im Winter, 6.

Histological Characters.

Brendel, *l. c.* 31.—Flot, Ann. Sc. Nat. 7 ser. xviii. 72.—Foerste, Bot. Gaz. 1892, 186.—Gris, Ext. Moelle Pl.

Lign. 42.—Hartig, Bot. Zeit. 1859, 106.—Houlbert, *l. c.* 156, 159, 163, 176.—Lecomte, Ann. Sc. nat. 7 ser. x. 218.—Mueller, Rinde Laubholz. 7.—Solereeder, Holzstructur, 245.

J. cinerea.

Winter Characters.

Beal, Amer. Naturalist, 1881. 36, fig.—Bösemann, *l. c.* 60.—Brendel, *l. c.* pl. 2, f. 17.—Powell, Amer. Gard. xiii. 708, fig.

Histological Characters.

Gnetzsch, *l. c.* 19.—Gris, Moelle Pl. Lign. 278; Extr. Moelle Pl. Lign. 21, pl. 6, f. 5.—Hough, Amer. Woods, i. 14 (3 wood sections).—Houlbert, *l. c.* 159.—Dawson, Amer. Journ. Pharm. xlv. 167.

J. nigra.

Winter Characters.

Beal, *l. c.* 36, fig.—Brendel, *l. c.* pl. 2, f. 18.—Döll, *l. c.* 21.—Feist, *l. c.* 327.—Hitchcock, Pl. Manhattan, 17; Key to Kas. Trees, 4, f. 13; Opening of Buds, 138, f. 99–101.—Rothrock, Forest Leaves, iv. 38–40, fig.—Schwarz, Forstl. Flora, 431.

Histological Characters.

Brooks, Wood Sects. 9 (3 wood sections).—Gerber, Jährl. Korkproduction, 27.—Gnetzsch, *l. c.* 19.—Hartig, Unterscheidungsmerkmale, 2 ed. 28; Engl. transl. 51.—Hough, Amer. Woods, ii. 35 (3 sects.).—Houlbert, *l. c.* 160.—Koeppen, Verhältn. d. Rinde uns. Laubbäume, pl. 21, f. 8, 16a.—Moeller, Anat. Baumrinden, 309, fig.—Nördlinger, Anat. Merkmale Wald- u. Gartenholzarten, 11.—Potonié, Sitzber. Bot. Ver. Prov. Brandenb. xxii. 81.—Tolman, Amer. Monthly Micr. J. xi. 55, f. 9.—Troschel, Mestom im Holze der dikot. Laubbäume. Diss. 1879, 19.

WINTER SYNOPSIS.

Hicoria, Raf. *Carya*, Nutt.

Pith not chambered (but sometimes cracking across at intervals when dry); buds frequently superposed, subnaked to evidently scaly, the lateral sometimes inclosed in a sac soon splitting at top, and often stalked; vernation of leaflets involute-convolute (pl. 23, f. 1); catkins not elongating until spring; fruit with the husk parted at least near the top, and usually deciduous.

* Bud scales 4 to 6, valvate in pairs, often with apical lobes and in some species more or less enlarging into leaves in spring, conspicuously yellow dotted (except sometimes in the first); larger lateral buds often long stalked; staminate catkins from lateral buds of the preceding year as well as at base of the new growth.—§ *Pacania* or *Apocarya*.

+ Outer bud scales more or less fused, loosening at base; terminal buds elongated except in the second.

++ Nut mostly elongated, subterete; the husk dehiscent nearly or quite to the base, its lobes usually with a raised margin.

1. H. PECAN (Marshall) Britton. *Carya olivaeformis*, Nuttall.—The Pecan.—A large tree; bark thick, buff gray, deeply fissured but not shaggy; twigs gray, with a shade of buff, dull, from tomentose-hirsute becoming nearly glabrous, the minute pale lenticels mostly inconspicuous the first year; buds elongated, gray, the terminal appressed, pubescent and yellow-glandular, the lateral soon nearly or quite glabrous; fruit 1 to 2 in. long; husk 2 to 3 mm. thick, splitting to the base, often persistent on the tree after the nut falls; nut ovoid to ellipsoid, more or less pointed at the ends, brown, irregularly flecked and striped with a darker color, 2-celled; shell firm, scarcely 1 mm. thick, the commissure weak and brown-spongy in the center; kernel sweet, little ruminated.—Iowa to southern Indiana, Kentucky, Louisiana and Texas, extending into Mexico,—in river bottoms.—Pl. 1, 2, 13, f. 1-3, 16, f. 7-11.

The fruit of the Pecan is one of the most variable nuts, some specimens being narrowly oblong while others are almost as broad as long. At the base, the commissure usually bears a delicate wing at each side, — an approach to the 4-celled base of other hickory nuts. The deeper color and conspicuous gloss of nuts from certain sections as they appear in the market does not indicate any botanical difference, but is the result of treatment which they undergo before being offered for sale.

In 1894, Mr. S. J. Galloway reported sweet-fruited nuts obtained from a single tree near Eaton, Ohio, which he believed to be a hybrid of the Pecan with some other species.* Of this tree, which appeared spontaneously some twenty-five yards from a cultivated Pecan, Mr. Galloway has been kind enough to send me ample flowering and fruiting specimens and twigs, which show that it resembles the Pecan in foliage and in the general form of the fruit and the character of the kernel, while it differs in having the staminate catkins stalked, as in other hickories, and in the nut, which, while elongated, is somewhat flattened, broader upwards, slightly marked by low-rounded prominences as in *H. minima*, acuminate pointed, only a little dark mottled, and evidently 4-celled for about 6 mm. from the bottom of the cavity. The twigs are slenderer than is usual in the Pecan, and nearly glabrous, and the slender buds are all conspicuously yellow dotted.—Pl. 16, f. 12–14, 20.

Mr. F. Reppert, of Muscatine, Iowa, has also placed in my hands specimens from several trees found near that city, which in aspect resemble the Bitternut, and in twig and bud characters approach the Galloway tree. The nuts, also, in shape and striping are more or less like the broader forms of Pecan nuts, though they are thinner shelled and 4-celled to a greater height, while the kernel is somewhat astringent.—Pl. 16, f. 15–16.

On the whole, the characters of these trees are inter-

* Gardening, Apr. 1, 1894, 226; Sargent, Silva, vii. 138.

mediate between the Pecan and Bitternut (*H. minima*), and they seem clearly to be hybrids of those species. The husk in most cases is intermediate in thickness between the two assumed parents. *Hickorea Texana*, Leconte* seems to be a similar hybrid, and the figure published by Leconte in his article represents quite well some of the nuts referred to above. Dr. Mohr † has reported the Pecan as hybridizing with the Water Hickory, but I have seen no specimens indicating this hybrid. The Pecan further hybridizes in an interesting way with the Mocker Nut and the Bottom Shellbark, under which species the hybrids are considered.

2. *H. MYRISTICAEFORMIS* (Michx. f.) Britton. *Carya myristicaeformis*, Nuttall.—The Nutmeg Hickory.—A medium sized tree; bark thin, dark brown-gray, falling in small scales or more shaggy and in netted flakes; twigs gray buff, dull, not hairy but at first densely covered with golden brown glistening peltate glands, the lenticels inconspicuous; buds ovoid, densely brown scurfy, the tomentose inner scales of the terminal soon exposed; fruit about 1 in. long, ellipsoidal; husk 1 to 2 mm. thick, splitting nearly to the base; nut ellipsoidal, mucronate at both ends, brown or gray, conspicuously dark striped, 4-celled below; shell very hard, 1 to 2 mm. thick, the commissure firm but dark lined; kernels sweet, not ruminated.—Arkansas to Alabama, Texas and Mexico, and in South Carolina,—in wet bottoms, occasionally extending into ravines and uplands; generally local.—Pl. 13, f. 7-9, 17, f. 1-4.

++ ++ Nut usually as broad as long, very thin shelled, flattened, 4-celled below.

3. *H. AQUATICA* (Michx. f.) Britton. *Carya aquatica*, Nuttall.—The Water Hickory.—A rather small tree, becoming large in Arkansas; bark thin, light gray, shaggy

* Proc. Philadelphia Acad. 1853, 402.

† Garden and Forest, 1889, 570.

exfoliating; twigs gray to very dark reddish-brown, then seeming almost black, often glossy, soon glabrous and at length nearly glandless, the few small white lenticels very evident; buds less stalked and rather shorter than is usual in the group, nearly black, evanescently yellow glandular, the terminal at first also sparingly hairy; fruit 1 to 2 inches long; husk 1 mm. thick, splitting to the base; nut very much flattened, umbonate to retuse at top, variously erosely ridged and angled, dull reddish-brown; shell soft, about .5 mm. thick, with large lacunae filled with a dark red spongy tissue, the commissure soft; kernel very bitter, much ruminated.— Virginia to Florida, around the Gulf to Texas, thence north to Arkansas and southern Illinois,— in wet bottoms, on gravelly river banks, etc.— Pl. 3, 4, 13, f. 4-6, 16, f. 1-3.

+ + Scales of terminal buds free above, all but the outermost developing into leaves; nut usually as broad as long, elliptical in cross section, 4-celled below.

4. H. MINIMA (Marshall) Britton.— *Carya amara*, Nuttall.— The Bitternut.— A medium sized to rather large tree; bark thin, light gray, with shallow fissures and separating somewhat in small thin flakes; twigs buff, exceptionally gray or reddish, rather dull, glabrous or slightly hairy at the end but usually very yellow glandular above, the numerous small pale lenticels evident; buds closely yellow dotted and somewhat pubescent between the scales, those superposed above the leaf scars often considerably separated and the uppermost of each series usually long stalked or lengthening into a twig the first season; fruit from less than an inch to an inch and a half long, obovoid to subglobose; husk 1 mm. thick, irregularly splitting to a little below the middle; nut sometimes broader than long, rounded at base, depressed and mucronate at top, slightly marked with rounded prominences conformed to the kernel, gray to buff, without darker stripes; shell very soft, .5 mm. thick, the commissure soft; kernel very bitter, ruminated.— Canada and Maine to Minnesota and

Nebraska, south to Texas and Florida,—in various situations.—Pl. 5, 6, 13, f. 10–12, 16, f. 4–6.

Apparently the Bitternut hybridizes with the Pecan, the hybrids more or less closely approaching the former in twig and foliage characters and in the thinness of shell and the form of the nut, while they more nearly resemble the latter in the striping and nearly 2-celled structure of the nut, which, while less bitter than in true *minima*, is usually decidedly astringent.

* * Buds always truly scaly, their scales 10 or more, imbricated or the outermost on lateral buds usually a closed sac soon splitting from the top, the inner hairy; staminate catkins at the base of the new growth only, each group of three on an exserted common peduncle; nuts (except in forms referred to under *ovata* and *laciniata*) firm shelled, 4-celled at base; kernel not ruminated.—§ *Euhicoria* or *Eucarya*.

+ Buds small (5 to 10 mm. long), becoming subglobose toward spring, their outer scales commonly glandular dotted; twigs glabrate, cherry colored to gray, slender for the group.

5. H. GLABRA (Miller) Britton. *Carya porcina*, Nuttall.—The Pignut.—A medium sized tree; bark thick, dark gray, checked much like that of the mature white ash; twigs purplish to dull gray, often without conspicuous lenticels; buds reddish brown to gray, silky after parting the outer scale; fruit about an inch long, pyriform, mostly apophysate, elliptical in cross section; husk about 1 mm. thick, rarely splitting far, and never below the middle; nut ellipsoidal, not angled, pointed from the mostly sunken apex, usually mucronate at the base, dirty brown; shell about 2 mm. thick, the commissure stout; kernel of inferior quality. Two forms of fruit occur, the longer marking the variety *ficiformis*, and the shorter the variety *obcordata*, but these appear scarcely worthy of varietal separation.—So far as my specimens show, limited to the Atlantic region, from Massachusetts and Pennsylvania to Florida.—Pl. 7, 14, f. 1, 17, f. 5–6.

Var. ODORATA (Marshall) Sargent.—Bark rough fissured, as in the Mockernut, or sometimes resembling the

white elm, but not shaggy; twigs often nearly red; fruit ellipsoidal to subglobose, rarely apophysate, the evident articulation close to its base; husk splitting almost to the base, often at first with raised lines along the sutures; nut gray or brownish, somewhat angled.— From the Mississippi Valley eastward, and from Canada to the Gulf, — mostly in uplands.— Pl. 8, 14, f. 3-5, 17, f. 9-14.

Var. *VILLOSA*, Sargent.— Bark deeply fissured and very rough, but not at all shaggy; twigs very slender, red, mostly tomentose; fruit about as in the preceding variety; nut mostly very brown, thick shelled and strongly angled, resembling the Mockernut.— Missouri, on flinty hills.— Pl. 9, 14, f. 6, 18, f. 1-2.

Var. *MICROCARPA* (Nuttall) Sargent.— Bark more or less shaggy, often as rough as in the Shagbark; fruit subglobose; husk often glossy, splitting nearly to the base; nut mostly gray or whitish, angled, rather thin shelled for the group, the kernel sweet.— Same range as the variety *odorata*.— Pl. 10, 14, f. 2, 17, f. 7-8.

Of all of the hickories, this is the most variable, as it is now understood, and I am far from satisfied with any arrangement of its forms that has yet appeared. In the character of the bark, form and dehiscence of fruit, and size, shape, color, hardness and degree of angling of the nut, differences are met with that would generally furnish specific or at least varietal characters, and to a certain extent this is true of the number of the leaflets; yet these differences, which individually are marked, occur so variously combined that little dependence can be placed on them separately. It seems evident, however, that the typical eastern Pignut, with nearly indehiscent husk, does not occur west of the Alleghenies, being replaced in the west by the dehiscent fruited form that I have designated as variety *odorata*, which so insensibly merges into *microcarpa* as to make any separation of these two purely arbitrary, unless the shaggy bark of the latter furnishes a character always to be trusted by association with the whiter, thinner shelled nuts

which are observable in much of the form named *microcarpa*.

As a rule the prevalent number of leaflets in both of these forms seems to be 5, while their number is rarely more than 3 in the eastern Pignut, with which, as will be seen, the other two forms are likely to be associated east of the Alleghenies. The hairy hill form, called *villosa*, not infrequently bears nuts which, separated from husk and twig, might easily pass for extreme forms of the Mockernut, and I was for a time inclined to consider this variety a hybrid with the latter, but this opinion does not appear to be substantiated by a fuller knowledge of the facts. In the southern Appalachian region are also found trees with leaves persistently tomentose until the maturity of the fruit, which are deserving of further study.

+ + Buds large (the terminal 8 to 15 mm. long), ovoid, nearly or quite glandless; twigs frequently somewhat tomentose at end, buff, gray or brownish, usually much stouter.

+ + Bark not shaggy; outer scales of terminal buds soon deciduous; husk of medium thickness, not parted quite to the base; nut angular but not much broader than thick.

7. H. ALBA (L.) Britton. *Carya tomentosa*, Nuttall.—The Mockernut.—A medium sized tree; bark gray, rather thin, deeply fissured and also checked into minute scales; twigs rather stout, mostly reddish-gray and with conspicuous lenticels, often tomentose; terminal buds densely hairy, broadly ovoid, obtuse to very acute, the outermost scales falling in early autumn, exposing the yellowish-gray silky inner scales, some of which fall during the winter; lateral buds red-brown, the outer scale often splitting only late; fruit one and a half to two and a half inches long, depressed globose to pyriform; husk 3 to 4 mm. thick, splitting to some distance below the middle; nut brown, from globose to narrowly ovoid-oblong, mostly somewhat flattened and (often obscurely) angled, usually acute at both ends and in the longer forms attenuate above; shell about 2 mm. thick and very hard, the commissure firm;

kernel of fair flavor, but frequently abortive and replaced by a spongy mass.—Canada to the Great Lakes and Kansas, south to Texas and Florida,— in uplands.—Pl. 11, 14, f. 7-9, 15, f. 1-3, 18, f. 3-10.

Occasional nuts, clearly of this species, occur with husks parted to the base and 7 to 12 mm. thick, suggesting hybridity with *ovata*, but I have not been able to study the trees from which they came. Other fruits suggest possible hybridity with the preceding species.

In the autumn of 1894, Dr. J. Schneck, of Mt. Carmel, Ill., and Mr. F. Reppert, of Muscatine, Iowa, sent to the herbarium twigs and fruit of bottom land trees that appear to be hybrids of this species with the Pecan.* The bark of the Iowa tree is described as being much like that of the Mockernut, while the tree of Dr. Schneck is smooth-barked, resembling the Pecan. So far as I have seen them the twigs of both might pass for those of *alba* except that the outer scales of the terminal buds are persistent, while the foliage, though intermediate, is strongly suggestive of that of the Pecan. The fruit is oblong, almost 2 in. long, the husk 6 mm. thick, parted nearly to the base, with strongly elevated margins to the segments, and rather persistent on the tree. The nuts are nearly as pale as in the Shagbark, conspicuously brown striped, slightly 4-celled at the very base, and with a wall only 1 mm. thick. As is usual in *alba*, they are upwardly attenuate, and frequently the kernel is abortive. It is not impossible that these hybrids represent the *Juglans rubra* of Lamarck (Illustr. iii. 365, pl. 781, f. 4) and of Gaertner (Fr. pl. 89).—Pl. 21, 23, f. 2-5.

++ ++ Bark shaggy; outer bud scales persisting through the winter; nut angular and flattened from the side.

= Fruit broader than long; husk moderately thick, not parted to the base.

8. H. MEXICANA (Engelm.) Britton. *Carya Mexicana*, Engelm.—A medium sized tree; bark “apparently

* On one of these see Sargent, Silva, vii. 138.

scaly; "twigs gray-brown, dull, glabrous, with numerous small but very evident pale lenticels; "buds ovate acute, about one-fourth inch long, with pubescent scales, the outer acuminate, often with subulate points;" fruit about an inch long, depressed; husk 6 mm. thick, splitting to below the middle; nut broader than high, mucronate at both ends, the apex truncate or depressed; shell nearly white and of a chalky appearance, sharply angled, nearly 2 mm. thick, with very thick commissure; kernel? — Mexico, known only from Palmer, 835½, from the high mountains of Alvarez, twenty miles southeast of San Luis Potosi, at an altitude of 8,000 ft.— The only species not native to the United States.— Pl. 19, f. 1-3.

In its husk characters and pubescence, this is most closely related to *H. alba*, but the bark (if really shaggy), bud, leaf and nut characters, bring it close to *H. ovata*.

= = Fruit subglobose or ellipsoidal; husk very thick, completely separating into 4 pieces; nut rather thin shelled, the kernel large and sweet.— In this group many of the petioles remain adherent to the twigs during the winter.

9. *H. LACINIOSA* (Michx.) Sargent. *Carya sulcata*, Nuttall.— The Bottom Shellbark.— A large tree; bark thick, light gray, coarsely flaking in very large scales with deep open sinuses, but usually less shaggy than in the next; twigs stout, buff or often nearly orange, mostly a little velvety or tomentose, with usually rather inconspicuous lenticels; terminal bud stout, with tomentose keeled outer scales; fruit ellipsoidal, two to two and a half inches long; husk about 10 mm. thick, finely velvety pubescent; nut longer than broad, mucronate at both ends, yellow; shell about 2 mm. thick, the commissure firm; kernel sweet.— New York and Pennsylvania to Iowa, Kansas, and the Indian Territory, — exclusively in river bottoms.— Pl. 15, f. 4-5, 19, f. 4-5.

In the American Agriculturist for 1884, p. 546, f. 1, Mr. A. S. Fuller published an account of a supposed hybrid between this species and the Pecan, which has been called the

Nussbaumer hybrid, after Mr. J. J. Nussbaumer, of Okawville, Ill., who first brought it to the attention of Judge Samuel Miller, of Bluffton, Mo. Mr. Nussbaumer writes me that the original tree, which stands in the bottom between Mascoutah and Fayetteville, Ill., in general appearance resembles *laciniosa*, though the bark is intermediate between that of the Pecan and Mockernut. Professor Sargent states (Silva, vii. 158) that a small tree grown from this in New Jersey by Mr. Fuller, cannot be distinguished from *laciniosa* of the same age; and I should hardly be able to distinguish an imperfect twig from a small tree, cultivated by Judge Miller, from *laciniosa*. The nut, however, is very peculiar, being more elongated than is usual in that species, and widened upwardly, less acutely angled "as if the ridges had been sandpapered down," and so thin shelled that it can be crushed easily by pressing two together in the palm of the hand. A somewhat similar nut, originally from Indiana, was described by Mr. Fuller in the New York Weekly Tribune, July 9, 1892 (Sargent's Silva, l. c.) as cultivated by Mr. R. M. Floyd, of Cedar Rapids, Iowa. And in the autumn of 1895, Dr. J. Schneck sent me ample fruit, twig and leaf specimens of a similar hickory from Posey County, Indiana. The nut of this last is almost identical with a specimen of the Nussbaumer nut in the Engelmann herbarium, while its twigs closely resemble those of *laciniosa*, and the leaves are decidedly of the Pecan type. I am led to the conclusion, therefore, that these several forms really represent hybrids between *H. Pecan* and *H. laciniosa*. In size, quality, and thinness of shell, they appear to be the most valuable of American nuts.—Pl. 22, 23, f. 6-9.

10. *H. ovata* (Miller) Britton. *Carya alba*, Nuttall.—The Shagbark or Shellbark.—A large tree; bark loosely flaking in large scales, the base of old trees merely checked; twigs slenderer, gray often tinged with red, only

exceptionally slightly tomentose, with numerous elongated white lenticels; buds somewhat smaller and with the nearly glabrous outer scales commonly longer pointed; fruit subglobose, about an inch and a half long; husk 5 to 8 mm. thick, glabrous; nut nearly one-half smaller than in the last, typically scarcely longer than broad, nearly white; shell 1 mm., the firm commissure very thin; kernel very sweet.—Canada to Minnesota, south to Florida, Kansas, and Texas,—in river bottoms and uplands.—Pl. 12, 15, f. 6–9, 19, f. 6–7.

Like the Pecan, the Shagbark has given rise to several superior races, some of which are cultivated.

JUGLANS, L.

Pith chambered, with persistent thin diaphragms; buds frequently superposed, the terminal subnaked, their leaves valvately arranged; vernation of leaflets conduplicate (pl. 25, f. 1), catkins mostly elongating somewhat in early winter; fruit with indehiscent persistent husk.

* Leaf scars little notched at top, surmounted by a yellow-velvety transverse prominence.

1. *J. CINEREA*, L. — The Butternut. — A medium-sized tree; bark gray, rather smooth between the deep fissures; twigs reddish-buff, with staring hairs or soon nearly glabrous, with numerous small white lenticels; pith dark brown, with narrow chambers little wider than the intervening diaphragms; terminal buds longer than broad, densely yellow-pubescent, the outer scales lobed at apex; fruit elongated, the husk villous, the nut 2-celled at base.—New Brunswick to Dakota, Kansas, and the mountains of Georgia and Alabama.—Pl. 24, f. 1–4.

Three Asiatic species, related by their buds and leaf scars to the Butternut, are more or less cultivated in the United States: — *J. Sieboldiana* (pl. 25, f. 3), with pale closely set pith plates, puberulent brown twigs with conspicuous

elongated lenticels, terminal buds little longer than broad, and ovoid terete nuts with honeycombed surface; *J. Mandshurica* (pl. 25, f. 4), with dark closely set pith plates, nearly glabrous somewhat glaucous reddish-brown twigs with very minute and inconspicuous lenticels, elongated buds, the lateral mostly on stalks of their own length, and ellipsoidal ridged and pitted nuts somewhat resembling those of *regia*; and *J. cordiformis* (pl. 25, f. 2), with pale, rather remote pith plates, brown twigs beset with very numerous long stiff ultimately deciduous brown hairs, the lenticels elongated but mostly inconspicuous, somewhat elongated buds often strongly curved to one side, and ovoid sharply acuminate strongly flattened and 2-edged nuts with nearly smooth surface.

* * Leaf scars evidently notched, not surmounted by a tomentose elevation; nut subglobose, somewhat 4-celled at base.

+ Western species; terminal buds elongated, their outer scales lobed above; fruit mostly small, the nut often only shallowly grooved and then with smooth rounded ridges.

2. *J. RUPESTRIS*, Engelmann.—The Southwestern Walnut.—A shrub or small tree; bark rather thick, gray, scaly; twigs slender, gray with a tinge of red or yellow, at first very densely buff-gray tomentose, the tomentum at length falling with the epidermis and exposing the small rounded pale lenticels; pith very small, brownish, with chambers several times as wide as the thin diaphragms; terminal buds twice as long as broad, somewhat olivaceous; nut often erosely roughened.—Texas, New Mexico and Arizona, extending into Mexico.—Pl. 24, f. 5-7.

3. *J. CALIFORNICA*, Watson.—The Californian Walnut.—A small or medium sized tree; bark thin, from whitish becoming dark brown; twigs stouter, glabrous except occasionally at the tip, and brown after the falling of the silvery epidermis, lenticels pale, very small but evident; pith large, slightly darker, otherwise as in the last; terminal buds somewhat less elongated, of the color of the twigs or gray-

ish; nut less deeply grooved.—Coast range of Southern California.—Pl. 24, f. 8–10.

+ + Eastern; terminal buds scarcely longer than broad, gray, their scales usually not evidently lobed; fruit large, the nut with prominent rough and sharp ridges.

4. *J. NIGRA*, L.—The Black Walnut.—A large tree; bark dark, deeply fissured and rough; twigs from densely gray tomentose becoming glabrous and reddish-buff, with small pale rather inconspicuous lenticels; pith buff, the open chambers usually several times as wide as the thin diaphragms; terminal bud mostly globose-conical, often almost silvery.—Massachusetts to Ontario and Minnesota, south to the Gulf.—Pl. 24, f. 11–13.

The European Walnut, *J. regia*, commonly cultivated in California, and to a less extent in the Atlantic States, resembles the last except that its bark is smoother and paler, and its twigs redder, often with a decided shade of green, mostly more dilated at the nodes and with broader more equally 3-lobed leaf scars, and glabrous, as are the lateral buds ultimately. In its typical form, the fruit is represented by the rather smooth thin shelled English Walnuts of the market.

Trees with the general characters of *regia*, but the fruit more or less resembling *nigra*, constitute the *Juglans intermedia* of European botanists,* some of whom hold these forms to represent hybrids between the two species named, while others are disposed to regard them as extreme forms of *regia*. Some years since Professor Rothrock † described a very peculiar walnut from the James River, in Virginia, and a somewhat similar fruit has been sent to our herbarium from the Wabash bottoms, by Dr. Schneck. More or less similar trees have been cultivated in European gardens, from American seed.‡ It is probable that some of these

* See, for instance, Robinson, Garden, ix. 363.

† Forest Leaves, ii. 133, with figures.

‡ See Vilmorin, Garden and Forest, iv. 51, with figures; Carrière, Revue Horticole, 1860, 100, and 1863, 30.

are actually of hybrid origin, while others, like the tree of Dr. Schneck, and those occurring spontaneously in Europe, are probably only aberrant forms respectively of *nigra* and *regia*. Quite recently Professor Sargent* has described and figured what he regards as a hybrid between *regia* and *cinerea*, the twigs of which are much more like those of *regia* than those of either of the supposed spontaneous hybrids that I have seen, though with more elongated buds and sometimes a little pubescent in the axils of the notched leaf scars. In the same article mention is made of several artificial hybrids produced in California by Mr. Luther Burbank, between *Californica* and both *nigra* and *regia*. Twigs of the first of these hybrids, for which I am indebted to Mr. Burbank, are downy and closely resemble those of *nigra* except that their gray terminal buds are usually twice as long as broad; while the twigs of the second are very stout, glabrous, and with large globose loosely gray tomentose buds.

EXPLANATION OF PLATES ILLUSTRATING JUGLANDACEAE.

The half-tones are from photographs taken by the author or contributed by correspondents whose donations are indicated in the description. The other plates are from drawings made by Miss Grace E. Johnson under the author's direction. Twigs, fruits and nuts are of natural size; twig details $\times 3$.

Plate 1.—*Hicoria Pecan*, an old tree 16 ft. in circumference, near Mt. Carmel, Ill. Photographed by Dr. Schneck.

Plate 2.—Bark of *Hicoria Pecan*, Caruthersville, Mo.

Plate 3.—Group of *Hicoria aquatica*, Campbell, Mo. Photographed by James Oxley.

Plate 4.—Bark of *Hicoria aquatica*,—one of the trees of Plate 3.

Plate 5.—*Hicoria minima*, Mt. Carmel, Ill. Photographed by Dr. Schneck.

Plate 6.—Bark of *Hicoria minima*, St. Louis, Mo.

Plate 7.—Bark of *Hicoria glabra*, Ithaca, N. Y. Photographed by Professor Rowlee.

* Garden and Forest, vii. 434; Silva, vii. 114.

Plate 8.—Bark of *Hicoria glabra*, var. *odorata*, Allenton, Mo.

Plate 9.—Bark of *Hicoria glabra*, var. *villosa*, Allenton, Mo.

Plate 10.—Bark of *Hicoria glabra*, var. *microcarpa*, Allenton, Mo.

Plate 11.—Bark of *Hicoria alba*, St. Louis, Mo.

Plate 12.—*Hicoria ovata*, near Mt. Carmel, Ill. Photographed by Dr. Schneck.

Plate 13.—1-3, *Hicoria Pecan*; 4-6, *H. aquatica*; 7-9, *H. myristicaeformis*; 10-12, *H. minima*.

Plate 14.—1, *H. glabra*; 2, *H. glabra, microcarpa*; 3-5, *H. glabra, odorata*; 6, *H. glabra, villosa*; 7-9, *H. alba*.

Plate 15.—1-3, *H. alba*; 4-5, *H. laciniosa*; 6-9, *H. ovata*.

Plate 16.—1-3, *H. aquatica*; 4-6, *H. minima*; 7-10, *H. Pecan*; 11, aberrant fruit of *H. Pecan* from Texas (Reverchon); 12-14, *H. Pecan* \times *minima* (Galloway); 15-16, *H. Pecan* \times *minima* (Reppert).

Plate 17.—1-4, *H. myristicaeformis*; 5-6, *H. glabra*; 7-8, *H. glabra, microcarpa*; 9-14, *H. glabra, odorata*.

Plate 18.—1-2, *H. glabra, villosa*; 3-10, *H. alba*.

Plate 19.—1-3, *H. Mexicana*; 4-5, *H. laciniosa*; 6-7, *H. ovata*.

Plate 20.—*H. Pecan* \times *minima* (Galloway), flowering shoot and winter twig, natural size; staminate flower, \times 6.

Plate 21.—*H. Pecan* \times *alba* (Schneck), twig and foliage, natural size.

Plate 22.—*H. Pecan* \times *laciniosa* (Schneck), twig and foliage, natural size.

Plate 23.—1, Vernation of *Hicoria*, after Engelmann; 2-5, *H. Pecan* \times *alba* (Reppert); 6, *H. Pecan* \times *laciniosa* (Schneck); 7-9, *H. Pecan* \times *laciniosa* (Nussbaumer).

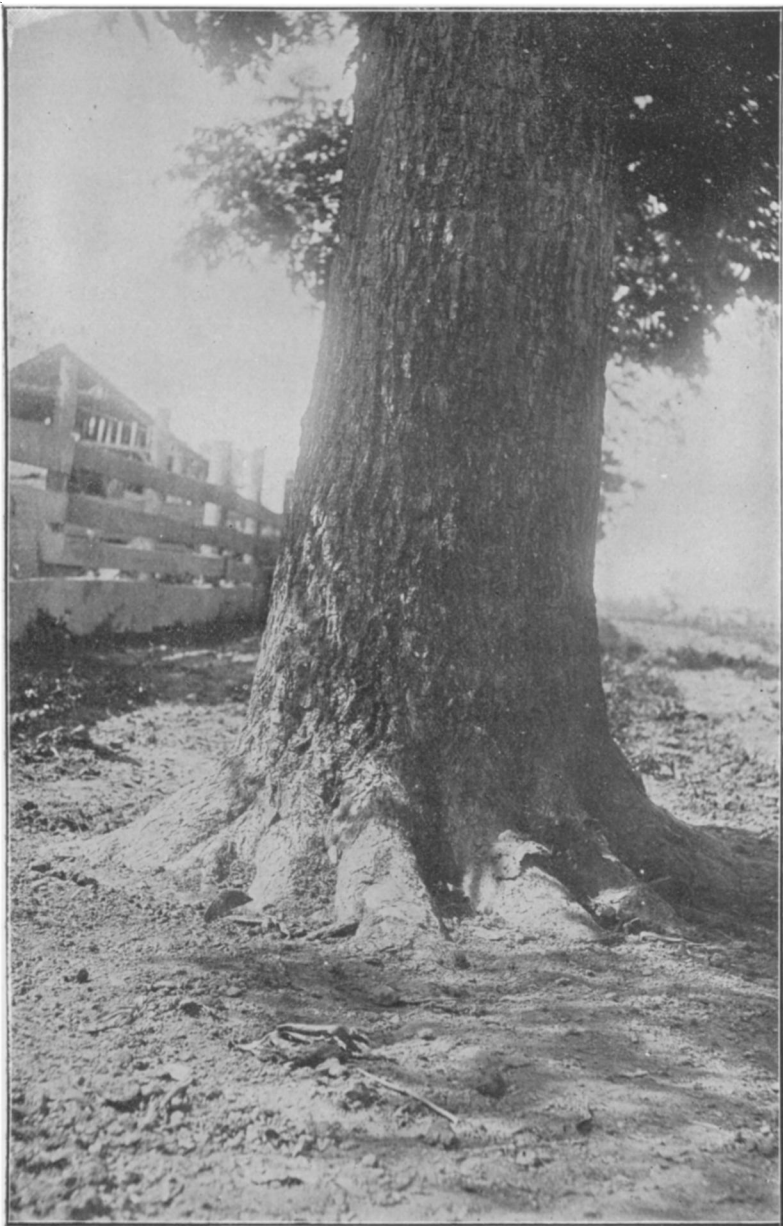
Plate 24.—1-4, *Juglans cinerea*; 5-7, *J. rupestris*; 8-10, *J. Californica*; 11-13, *J. nigra*.

Plate 25.—1, Vernation of *Juglans*, after Engelmann; 2, *J. cordiformis*; 3, *J. Sieboldiana*; 4, *J. Mandshurica*.

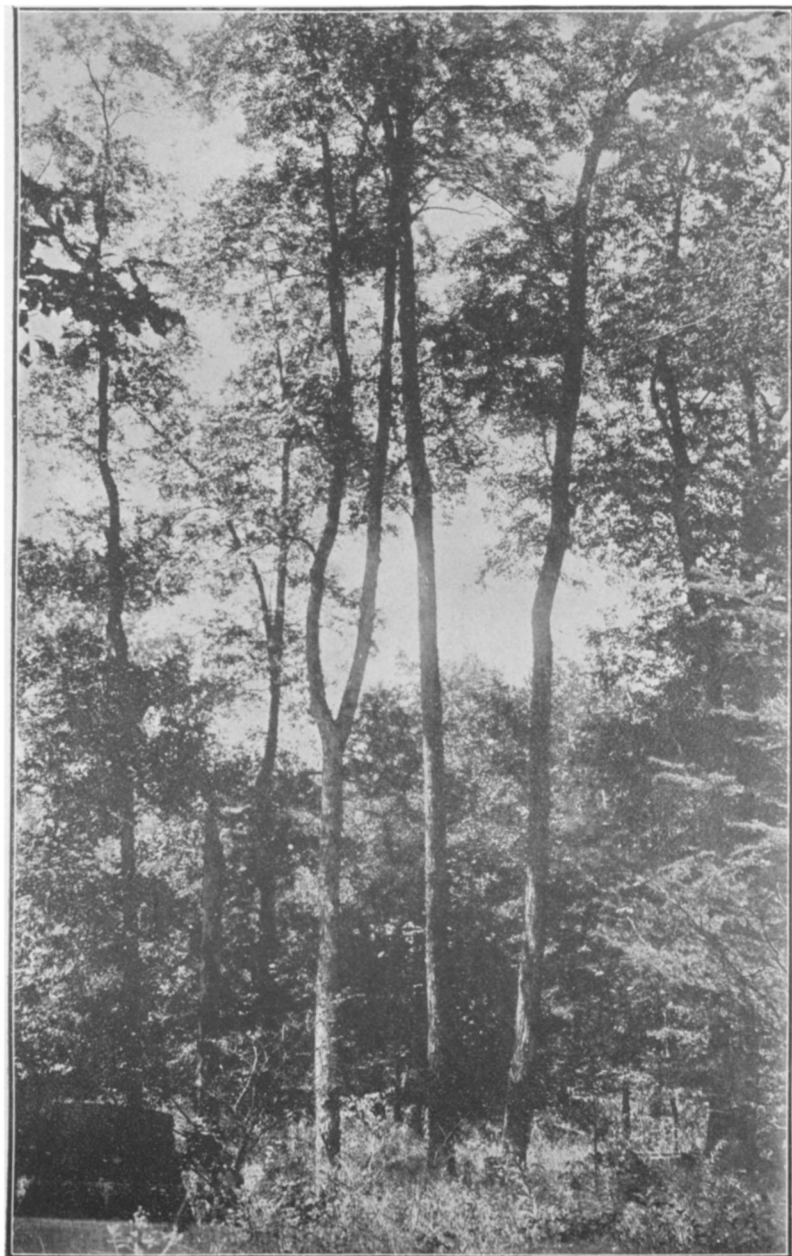
Since the preceding pages were cast, a bulletin on Nut Culture in the United States has been published by the Division of Pomology of the United States Department of Agriculture, which contains valuable information on the cultivated varieties of *Hicoria* and *Juglans* as well as good illustrations of the fruit of several species. The supposed hybrid pecan referred to above under *J. laciniosa*, is here (p. 62, pl. 9, f. 6) reported further from Mt. Vernon, Ind.



HICORIA PECAN.



HICORIA PECAN.



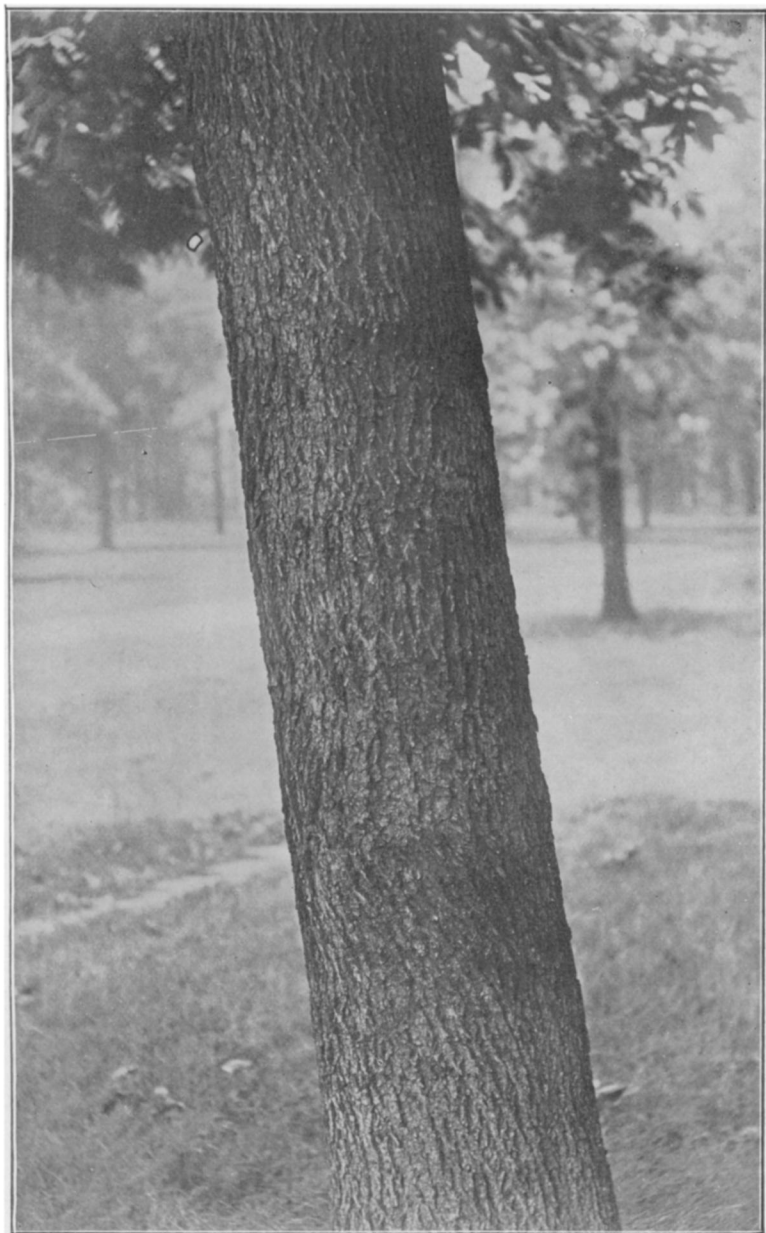
HICORIA AQUATICA.



HICORIA AQUATICA.



HICORIA MINIMA.



HICORIA MINIMA.



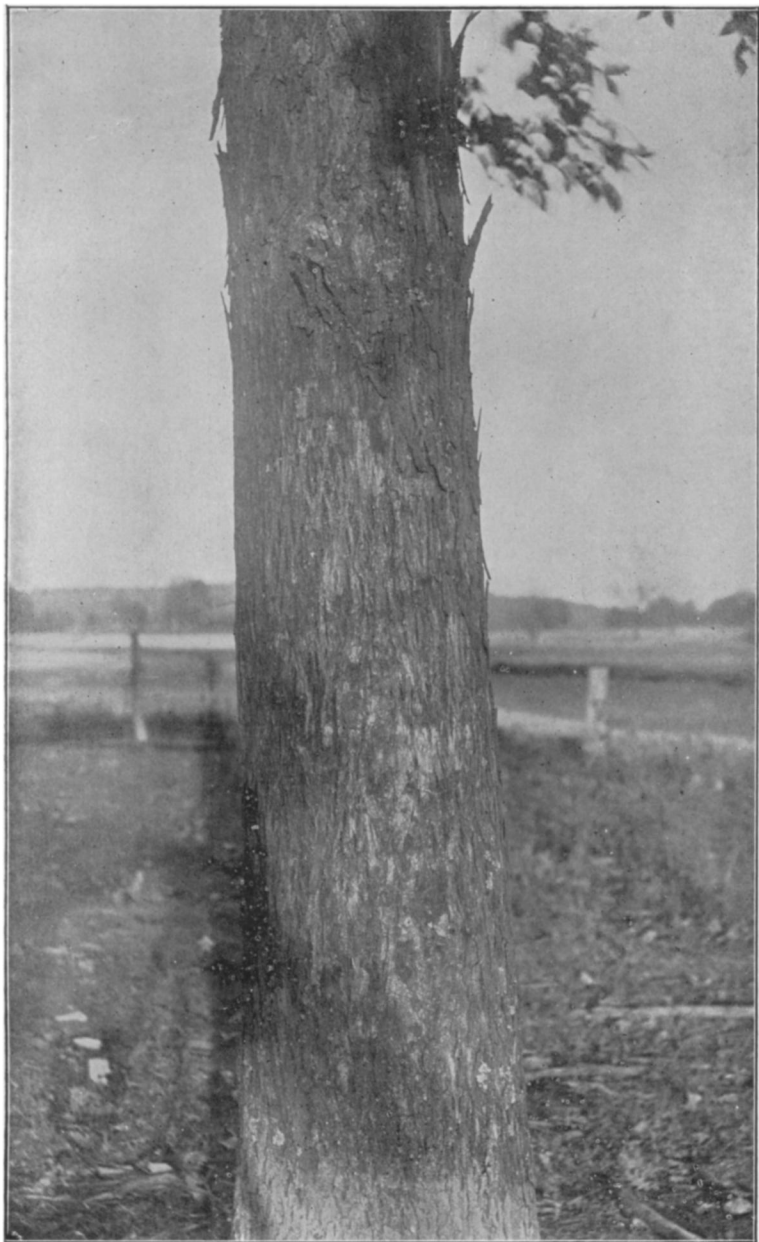
HICORIA GLABRA.



HICORIA GLABRA, VAR. *ODORATA*.



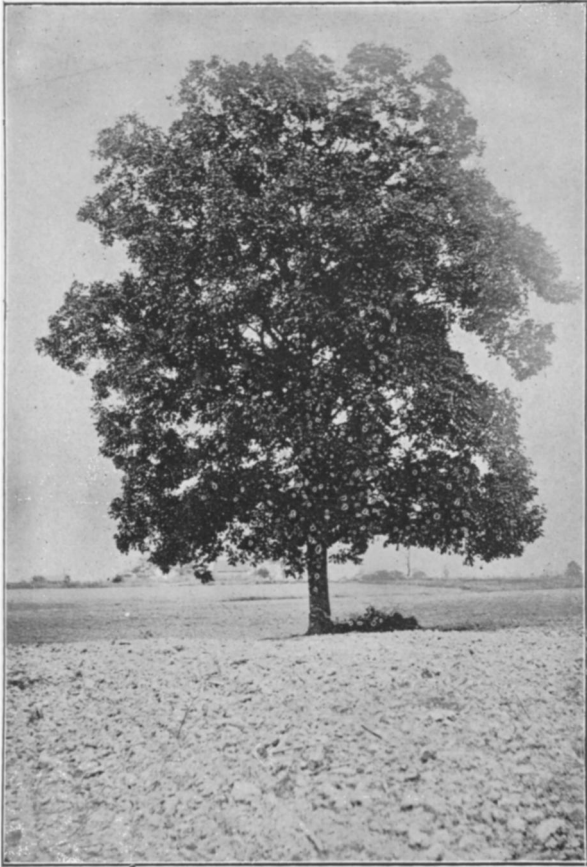
HICORIA GLABRA, VAR. *VILLOSA*.



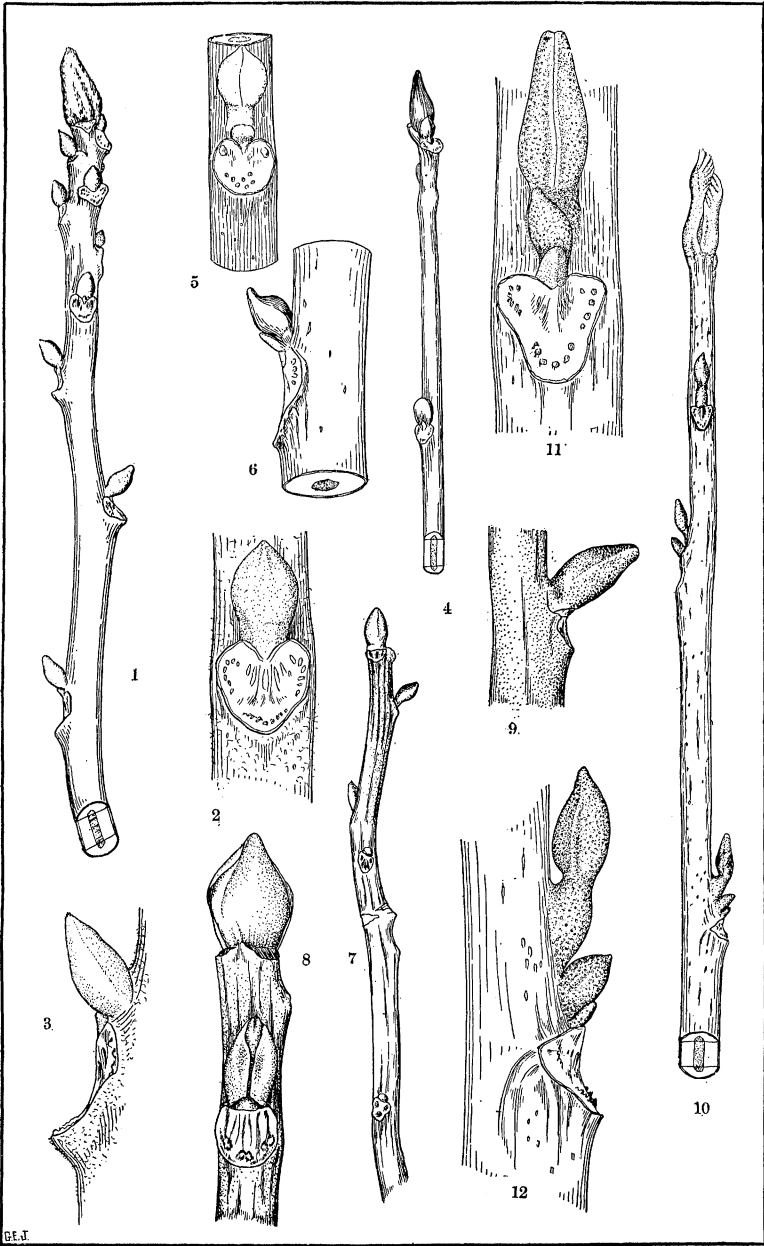
HICORIA GLABRA, VAR. *MICROCARPA*.



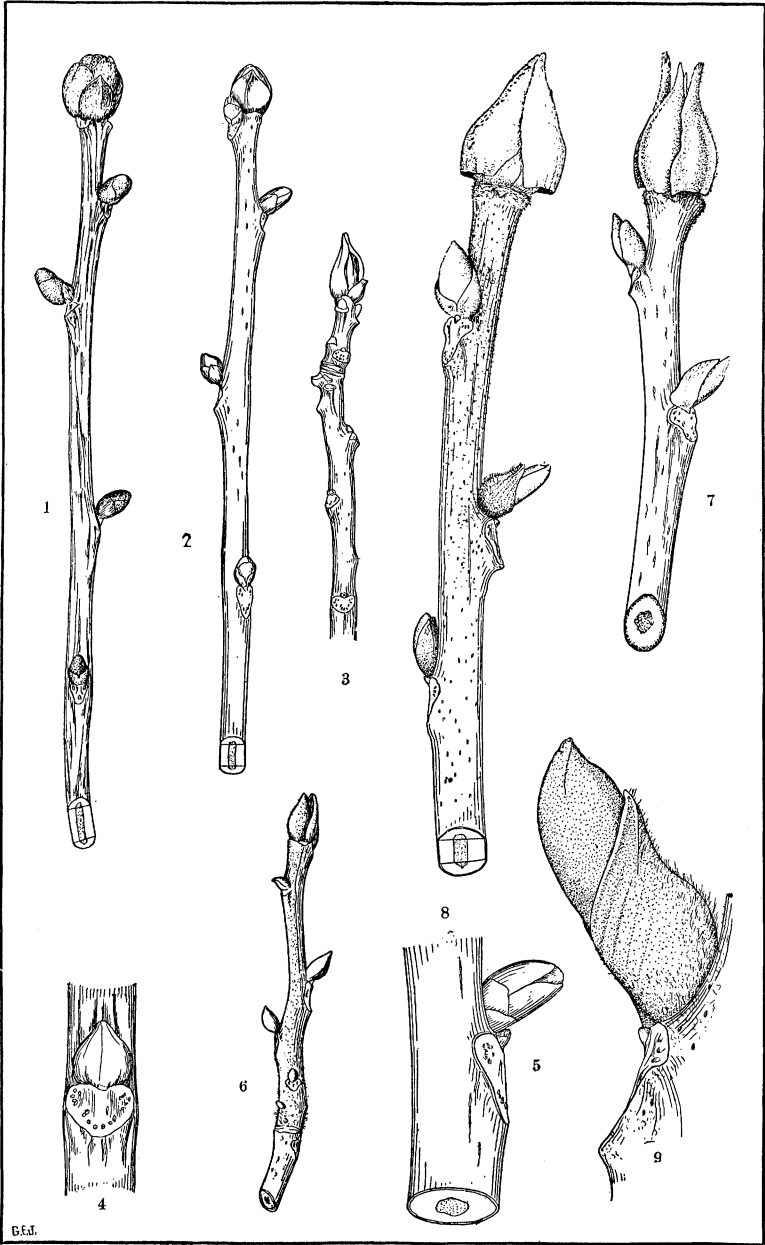
HICORIA ALBA.



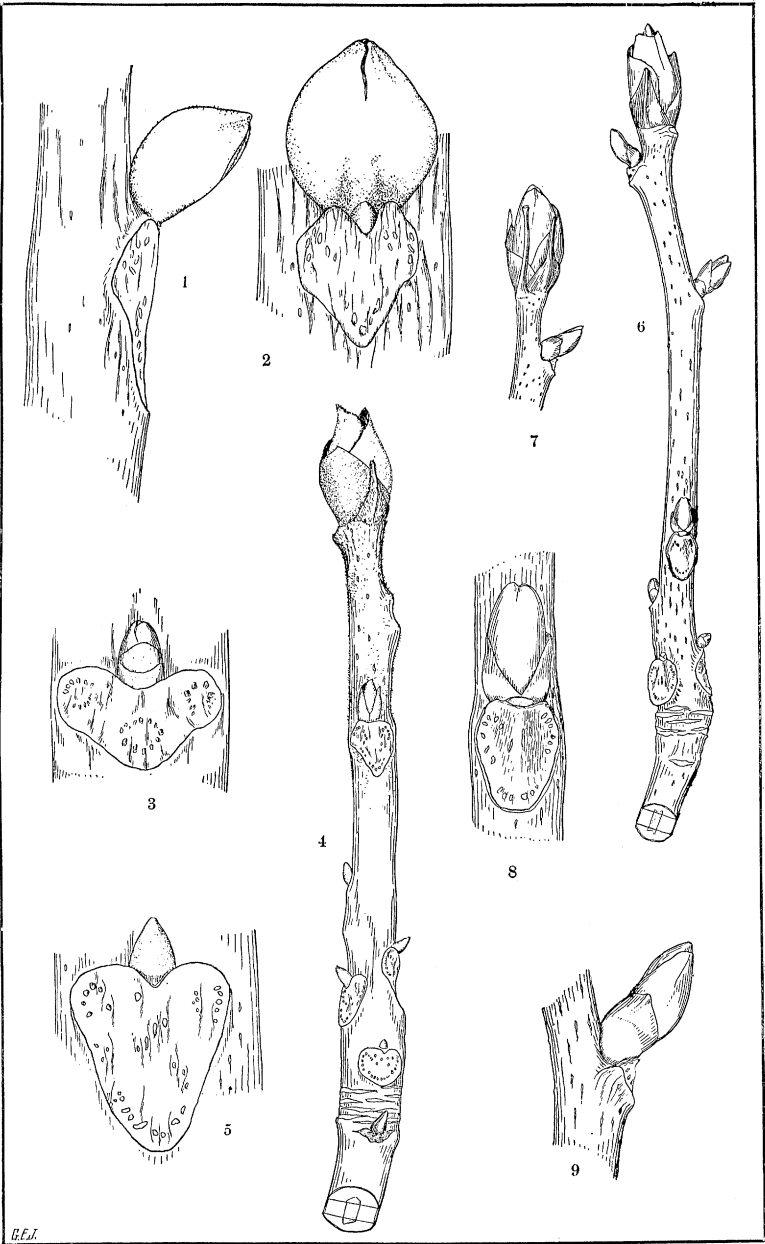
HICORIA OVATA.



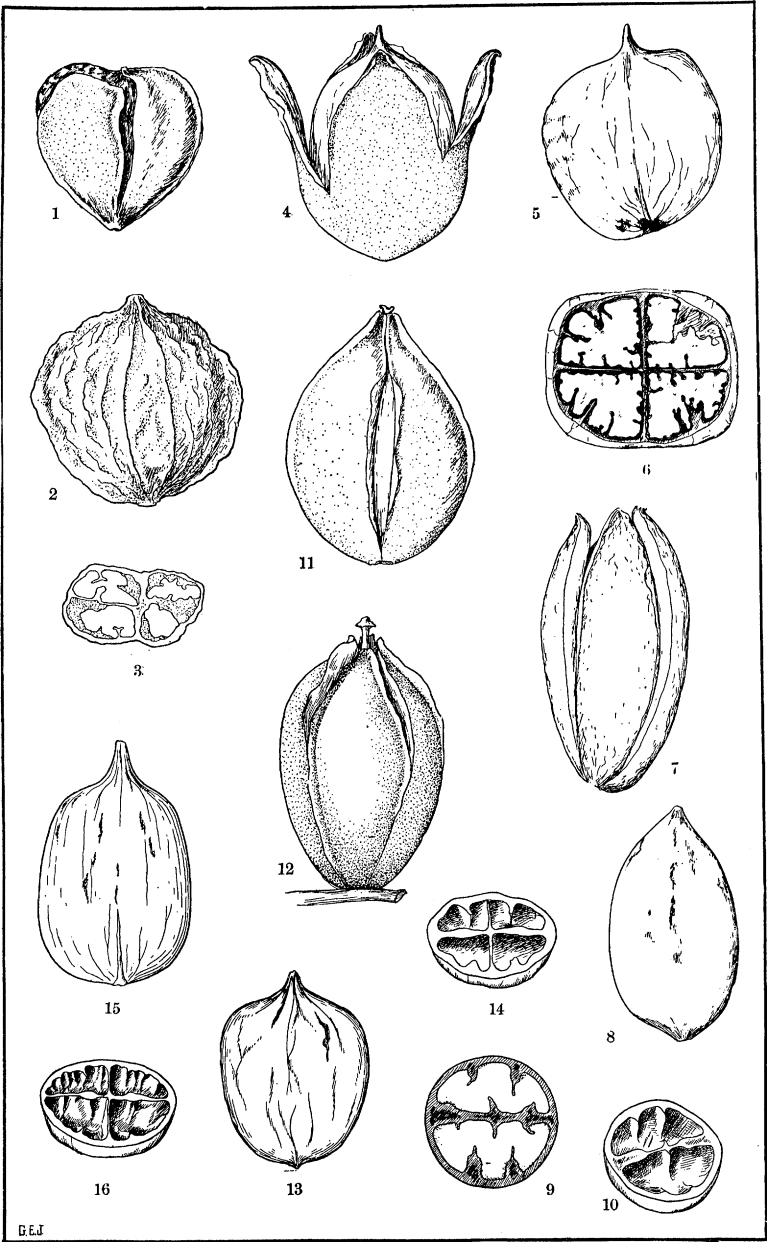
HICORIA, SECTION PACANIA.



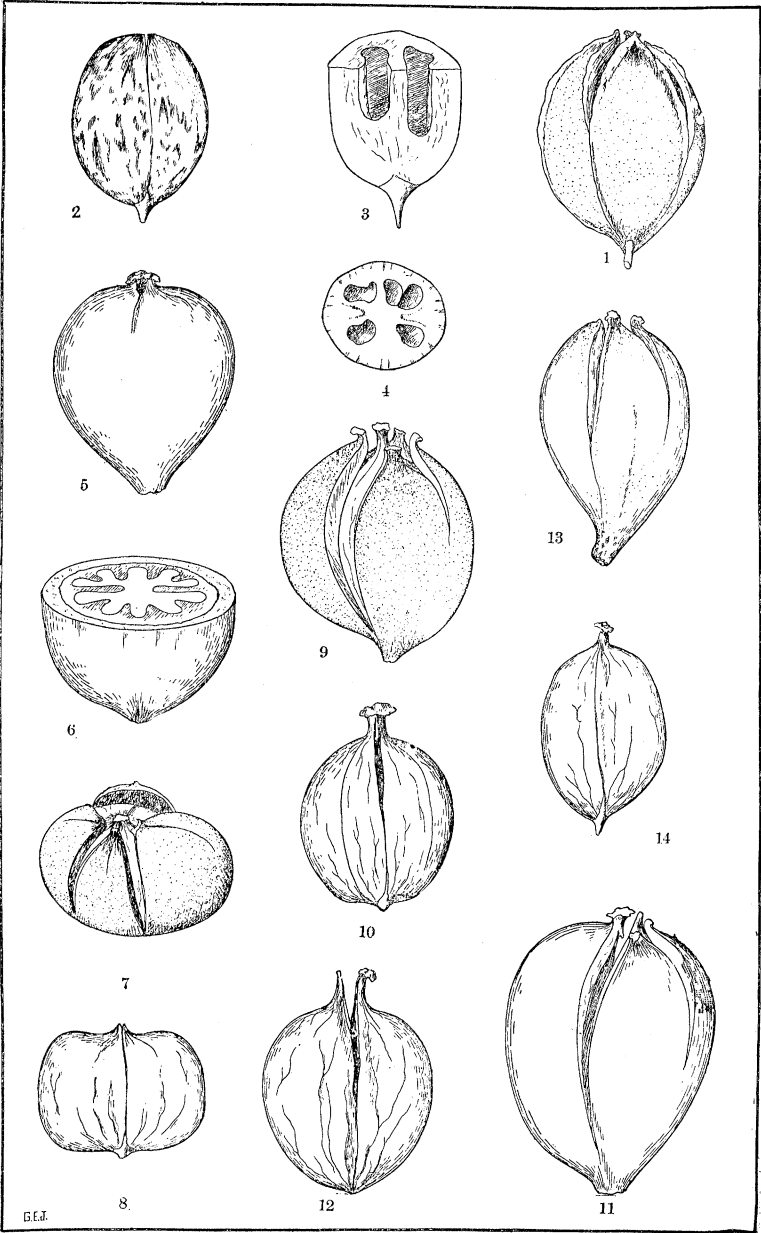
HICORIA, SECTION EUHICORIA.



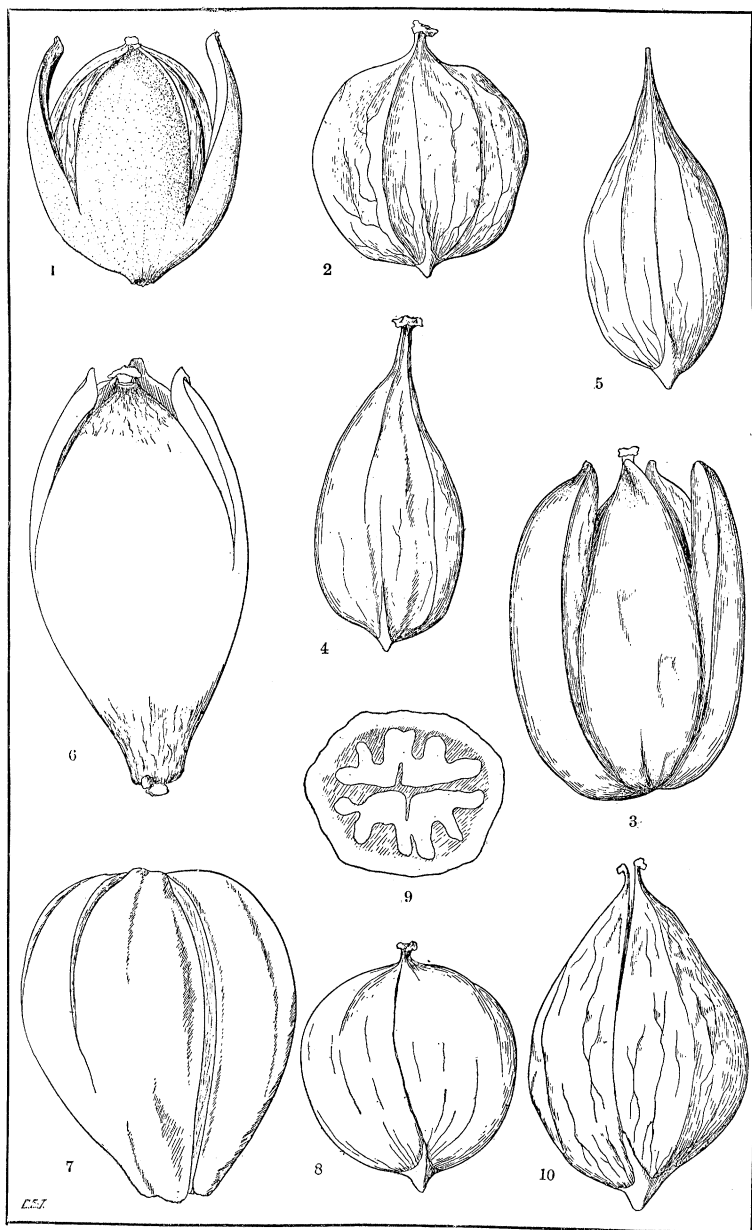
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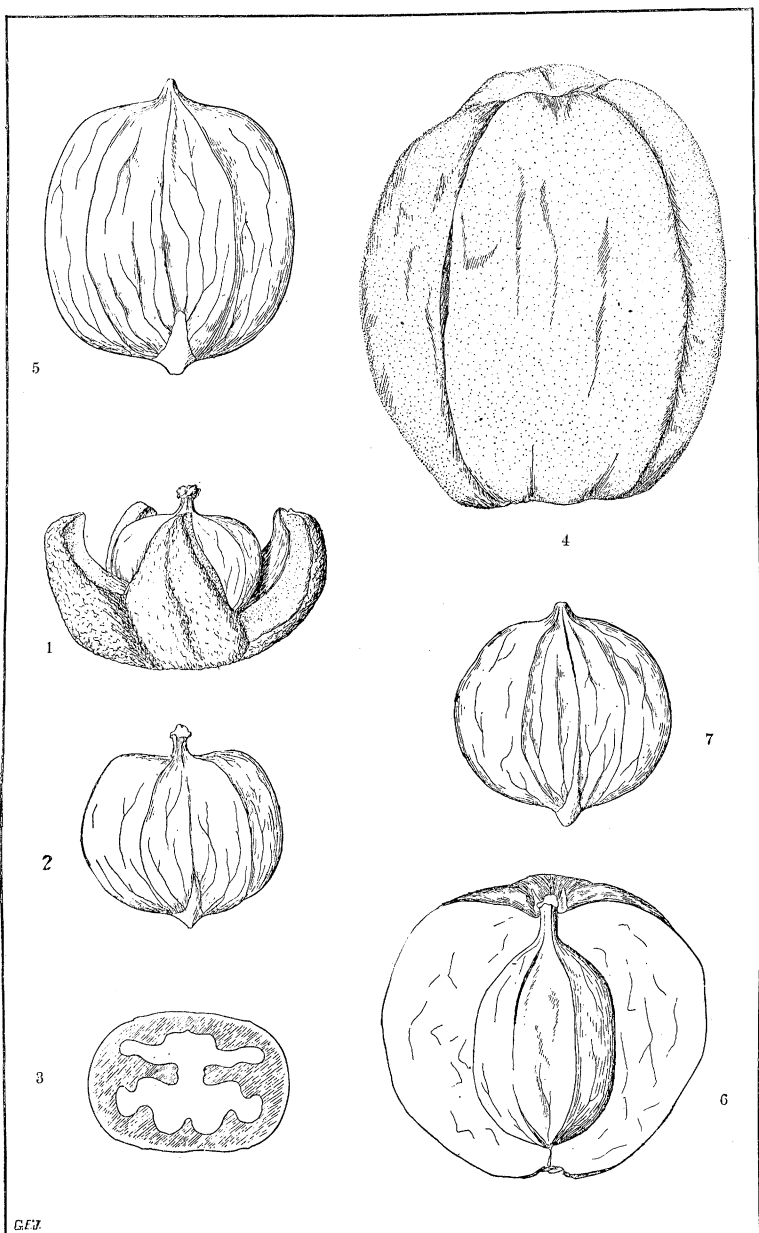
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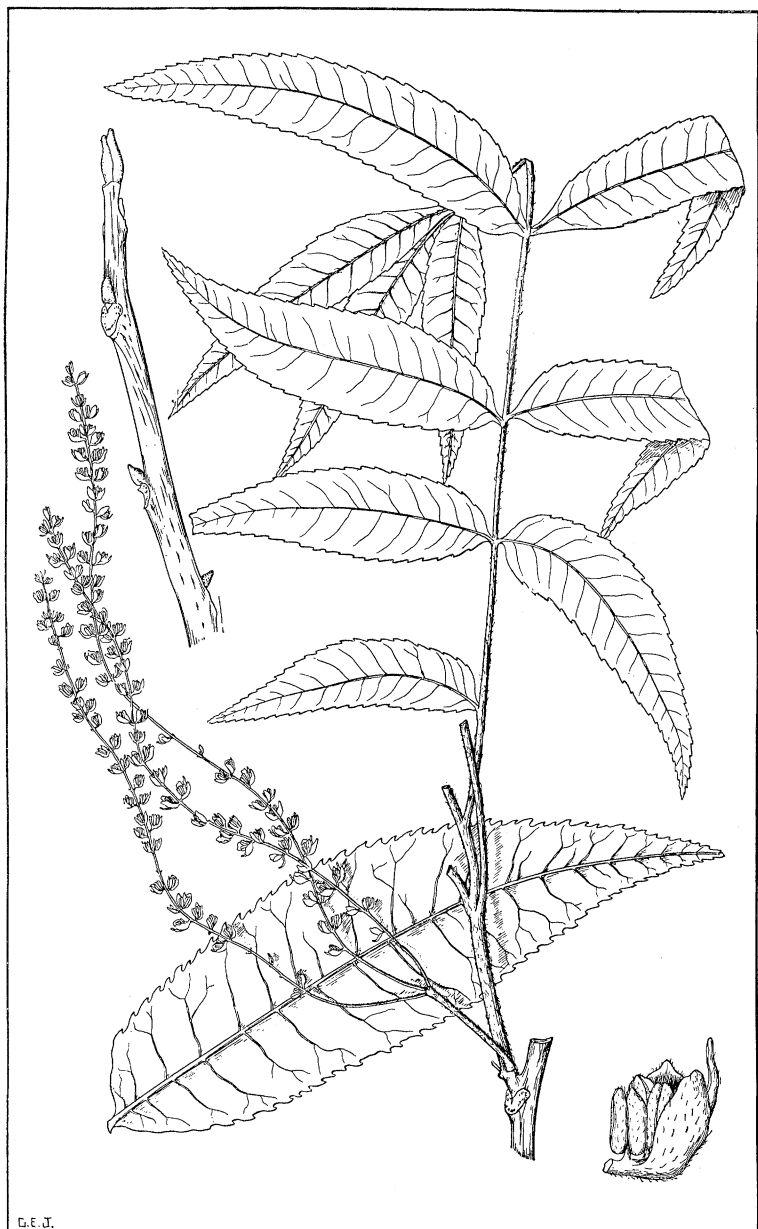
NUTMEG AND PIGNUT HICKORIES.



HICORIA, SECTION EUHICORIA.

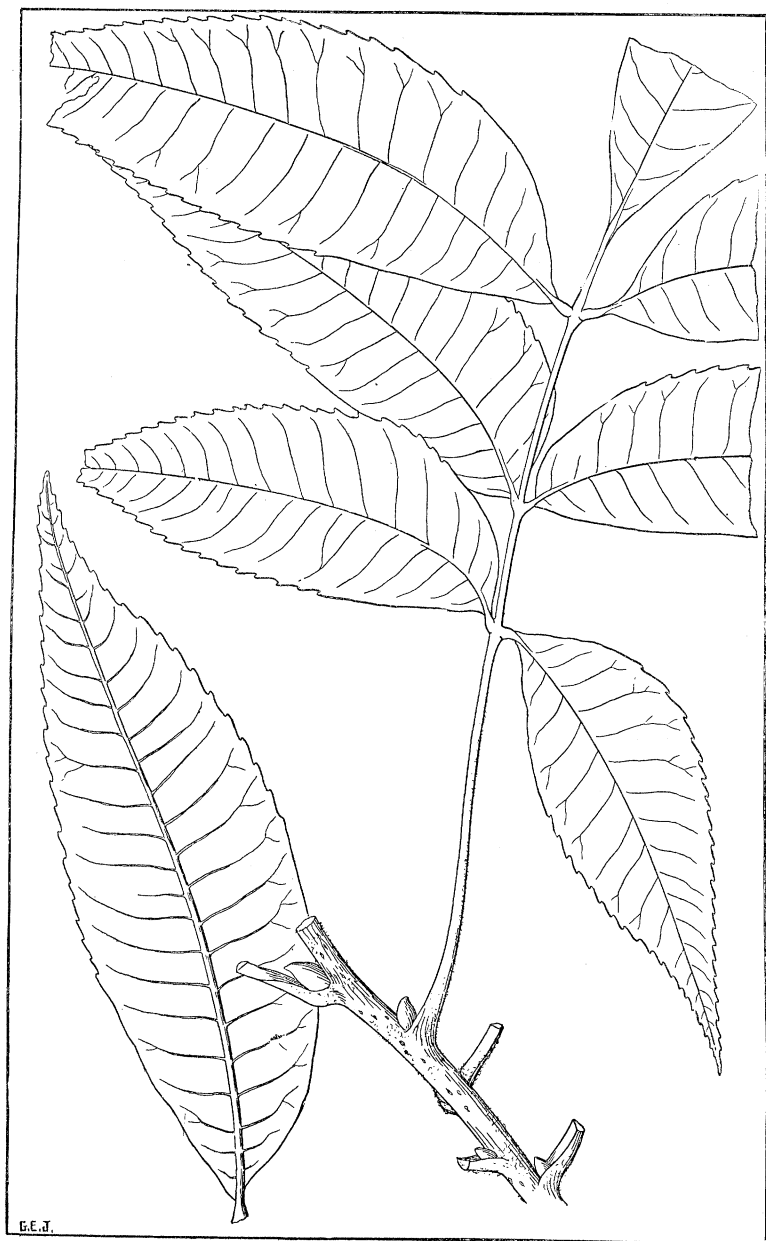


HICORIA, SECTION EUHICORIA.



G.E.J.

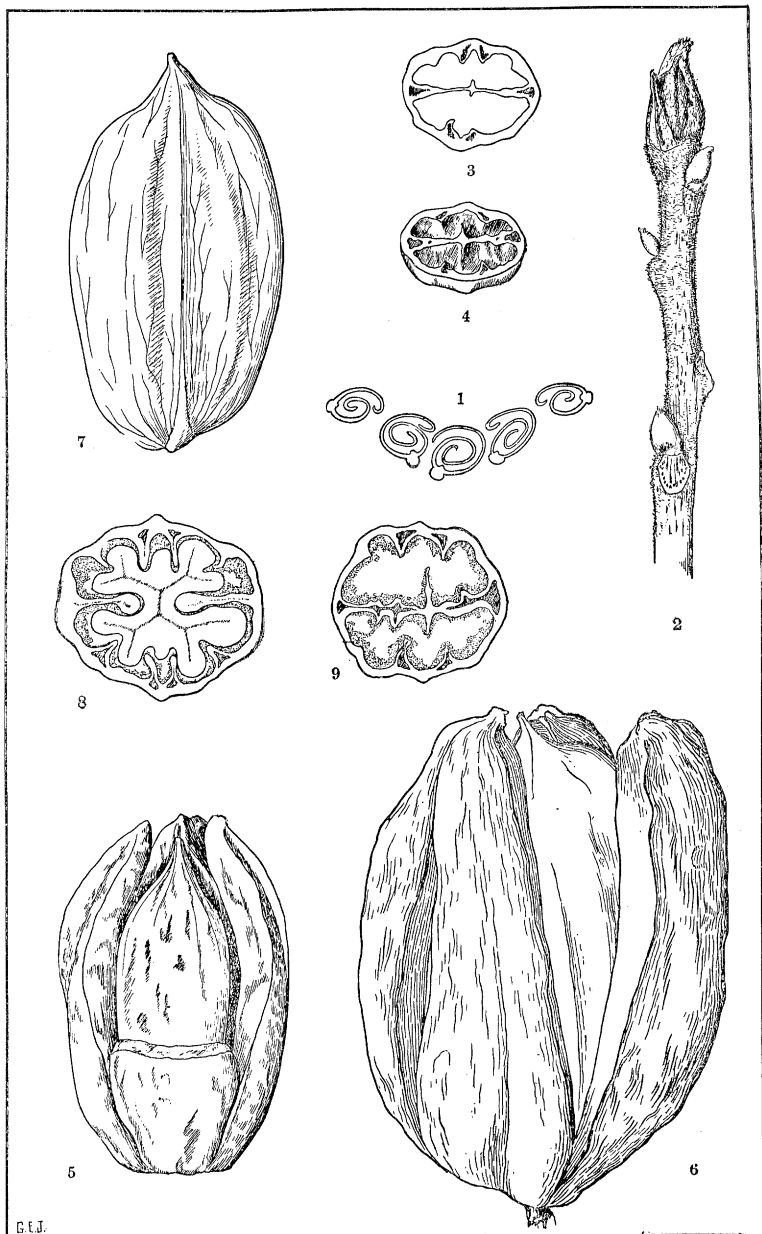
HICORIA PECAN \times MINIMA.



HICORIA PECAN \times ALBA.

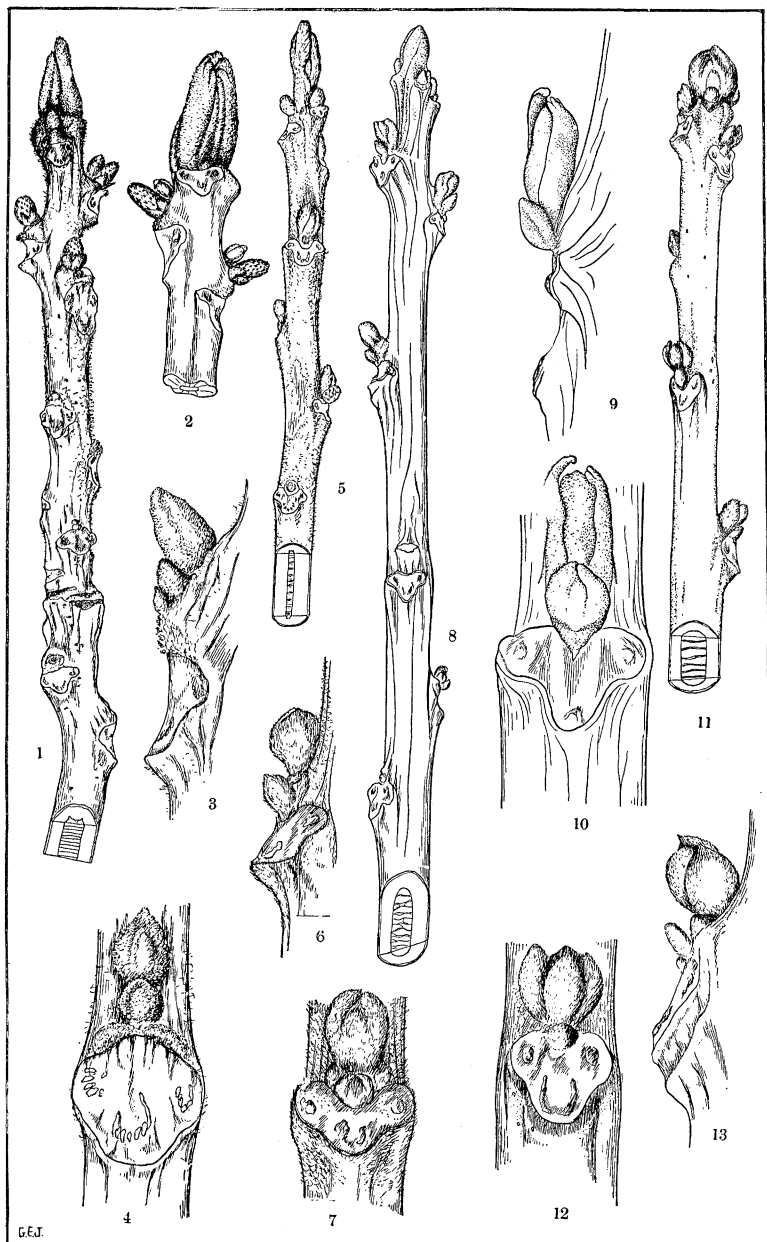


HICORIA PECAN \times LACINIOSA.

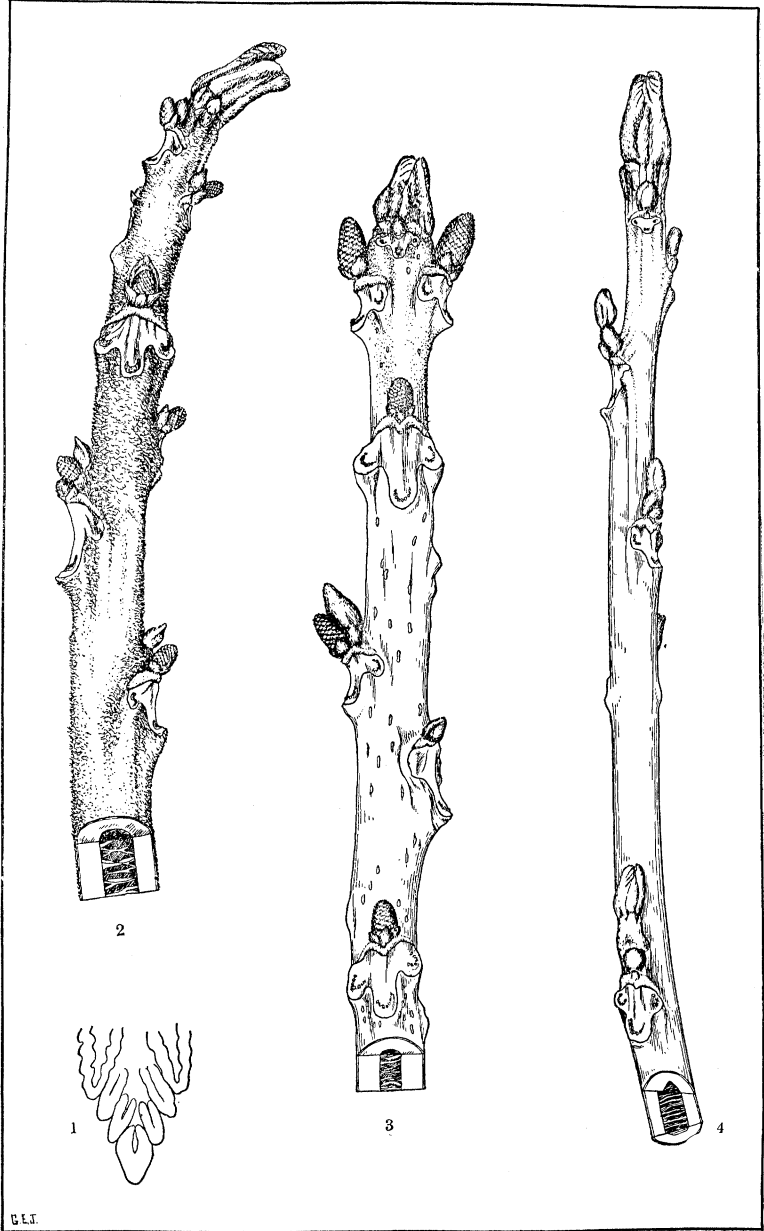


G. & J.

HICORIA HYBRIDS.



AMERICAN WALNUTS.



JAPANESE WALNUTS.